Earth Science Data and Information System Project, Code 423

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Operation IceBridge Data Management Plan

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National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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Operation IceBridge Data Management Plan

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Preface

This document is under ESDIS Project configuration control. Once this document is approved, ESDIS approved changes are handled in accordance with Class I and Class II change control requirements described in the ESDIS Configuration Management Procedures, and changes to this document shall be made by document change notice (DCN) or by complete revision.

This document contains information pertaining to the Operation IceBridge Data Management Plan.

Any questions should be addressed to:

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Abstract

This document is a detailed plan for all management of Operation IceBridge data throughout its five-year project lifecycle ending in 2017. Its content is applicable to all data providers and all data sets unless specific exceptions are made.

Keywords: IceBridge, NSIDC DAAC, CReSIS, LIDAR, WFF, GSFC, NSERC, CIRRUS, UARC, DMS, Lamont-Doherty, WISE

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Change Record Page

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1 Introduction

1.1 Scope

This document outlines a detailed plan for all aspects of Operation IceBridge data management throughout its five-year project lifecycle until 2017.Its content is applicable to all data providers and all data sets unless specific exceptions are made.

1.2 Mission Description

The Operation IceBridge mission, initiated in 2009, collects airborne remote sensing measurements to bridge the gap between NASA's Ice, Cloud and Land Elevation Satellite (ICESat) mission and the upcoming ICESat-2 mission. Operation IceBridge mission observations and measurements include coastal Greenland, coastal Antarctica, the Antarctic Peninsula, interior Antarctica, the southeast Alaskan glaciers, and Antarctic and Arctic sea ice.

Operation IceBridge combines multiple instruments to map ice surface topography, bedrock topography beneath the ice sheets, grounding line position, ice and snow thickness, and sea ice distribution and freeboard. Data from laser altimeters and radar sounders are paired with gravimeter, magnetometer, mapping camera, and other data to provide dynamic, high-value, repeat measurements of rapidly changing portions of land and sea ice.

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2 Requirements

2.1 Science Data Generation and Documentation

2.1.1 All Operation IceBridge data products shall conform to the terms and conditions of the NASA Earth Science Data and Information Policy, which can be found at: http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/.

2.1.2 Operation IceBridge data providers shall be assigned the responsibility of producing data products for their respective instruments.

2.1.3 To keep end-to-end consistency, Operation IceBridge data providers shall reprocess any given data product (in its entirety, including data from earlier IceBridge campaigns) that requires an algorithm change.

2.1.4 To keep end-to-end consistency, Operation IceBridge data providers shall reformat any given data product (in its entirety, including data from earlier IceBridge campaigns) that requires a format change.

2.1.5 By the end of mission, Operation IceBridge data providers shall provide all documentation necessary for final archival purposes as spelled out in the NASA Earth Science preservation document at: http://earthdata.nasa.gov/sites/default/files/field/document/423-SPEC-001_NASA ESD_Preservation_Spec_OriginalCh01_0.pdf

2.1.6 Operation IceBridge data providers shall provide documentation, as specified by NASA/NSIDC documentation content requirements located at: http://nsidc.org/data/icebridge/nsidc-guide-document-template-rev-01-june-2012-1.docx, to facilitate users' understanding and use of their data products.

2.1.7 Operation IceBridge data providers shall submit product documentation to the NSIDC DAAC as early as possible before the first delivery of a new product, and be available to work with NSIDC technical writers, to facilitate establishment of the new product. For subsequent data deliveries, data providers shall submit updates to documentation within one week after the submission of data to the NSIDC DAAC for ingest, archive and distribution.

2.1.8 Operation IceBridge L1B and L2 data products shall be organized and partitioned temporally, following each flight's trajectory.

2.1.9 Individual data files delivered to the NSIDC DAAC for archival shall not exceed 1 GB in size.

2.2 Science Data Format and Metadata

2.2.1 Operation IceBridge data product formats, with the exception of Level 0 or raw data, shall conform to one of the NASA Earth Science Division (ESD) approved Data System standards. The formats will be selected in collaboration with the ESDIS Project and documented in Section 4 of this Data Management Plan. The list of existing approved standards, along with guidelines for approval of new standards, can be found at: http://earthdata.nasa.gov/data/references/data-format-standards. Once decided upon and agreed to, a data set's format should be kept consistent for all future deliveries, unless renegotiated with a plan for reprocessing of existing data.

2.2.1 All data submissions to the NSIDC DAAC shall have accompanying spatial, temporal, and product metadata that adhere to ESD-approved specifications at: http://earthdata.nasa.gov/data/standards-and-references/metadata-standards.

3 Providers, Products, and Deadlines

This section describes each of the individual data providers, their instruments, the data products that they generate, and their associated submission deadlines. For each data product, the following information is provided.

- Product collection short name
- A brief product description
- Data processing level
- Data format
- Estimated data volume per campaign (GB)
- Submission schedule
- Provider contact information
- Delivery mechanism

3.1 University of Kansas Center for Remote Sensing of Ice Sheets (CReSIS)

The Center for Remote Sensing of Ice Sheets (CReSIS) is a Science and Technology Center established by the National Science Foundation (NSF) in 2005, with the mission of developing new technologies and computer models to measure and predict the response of sea level change to the mass balance of ice sheets in Greenland and Antarctica. The NSF's Science and Technology Center (STC) program combines the efforts of scientists and engineers to respond to problems of global significance, supporting the intense, sustained, collaborative work that is required to achieve progress in these areas.

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3.1.1 Instruments and Science Data Products

3.1.1.1 Accumulation Radar

This radar provides fine depth resolution profiling of the top 100 m of the ice column. It is designed to map variations in the snow accumulation rate. When operated from aircraft, it operates from 600 to 900 MHz providing 28-cm depth resolution in ice and when operated on the ground (500 MHz to 2 GHz) a 5.6-cm depth resolution in ice is achieved.

Table 3.1. Accumulation Radar Products

Short Name	Product Description	Data Level	Format	Est. Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRACC1B	IceBridge Accumulation Radar L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	100	4 months	FTP

3.1.1.2 Ku-Band Radar Altimeter

This wideband radar altimeter operates over the frequency range from 13 to 17 GHz. The primary purpose of this radar is high precision surface elevation measurements over polar ice sheets. The data collected with this radar can be analyzed in conjunction with laser-altimeter data to determine thickness of snow over sea ice.

Table 3.2. Ku-Band Radar Altimeter Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRKUB1B	IceBridge Ku-Band Radar L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	250	4 months	FTP
IRKUB2	IceBridge Ku-Band Radar L2 Ice Surface Elevation	2	CSV	1	4 months	FTP

3.1.1.3 Multichannel Coherent Radar Depth Sounder (MCoRDS)

This radar operates over the frequency range from 140 to 230 MHz with multiple receivers developed for airborne sounding and imaging of ice sheets. The radar bandwidth is adjustable from 20 MHz to 60 MHz. Multiple receivers permit digital beamsteering for suppressing cross-track surface clutter that can mask weak ice-bed echoes and strip-map synthetic aperture radar (SAR) images of the ice-bed interface. With 200 W of peak transmit power, a loop sensitivity > 190 dB is achieved.

Table 3.3. MCoRDS Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRMCR1B	IceBridge MCoRDS L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	100	4 months	FTP
IRMCR2	IceBridge MCoRDS L2 Ice Thickness	2	CSV	1	4 months	FTP
IRMCR3	IceBridge MCoRDS L3 Gridded IceThickness, Surface, and Bottom	3	NetCDF	1	6 months	FTP

* IRMCR3 volume per campaign is dependent on availability of flight grids and community need for gridded products.

3.1.1.4 Snow Radar

This ultra-wideband radar operates over the frequency from 2 to 8 GHz to map near-surface internal layers in polar firn with fine vertical resolution. The radar has also been used to measure thickness of snow over sea ice. Information about snow thickness is essential to estimate sea ice thickness from ice freeboard measurements performed with satellite radar and laser altimeters.

Table 3.4. Snow Radar Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRSNO1B	IceBridge Snow Radar L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	250	4 months	FTP
IRSNO2	IceBridge Snow Radar L2 Snow Depth	2	CSV	1	4 months	FTP

3.2 NASA Wallops Flight Facility

NASA Goddard Space Flight Center's Wallops Flight Facility, located on Virginia's Eastern Shore, was established in 1945 by the National Advisory Committee for Aeronautics, as a center for aeronautic research. The research and responsibilities of Wallops Flight Facility are centered on the philosophy of providing a fast, low cost, highly flexible and safe response to meet the needs of the United States' aerospace technology interests and science research.

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3.2.1 Instruments and Science Data Products

3.2.1.1 Airborne Topographic Mapper (ATM)

The ATM is a scanning Laser Imaging Detection and Ranging (LIDAR) developed and used by NASA for observing the Earth's topography for several scientific applications, foremost of which is the measurement of changing Arctic and Antarctic icecaps and glaciers. It typically flies on aircraft at an altitude between 400 and 800 meters above ground level, and measures topography to an accuracy better than ten centimeters by incorporating measurements from global positioning system (GPS) receivers and inertial navigation system (INS) attitude sensors.

Table 3.5. ATM Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILATM1B	IceBridge ATM L1B Qfit Elevation and Return Strength	1B	HDF5	100	6 months following deployment end	FTP to NSIDC
ILATM2	IceBridge ATM L2 Icessn Elevation, Slope, and Roughness	2	Fixed format ASCII	2	6 months following deployment end	FTP to NSIDC
	IceBridge ATM L2 dh/dt	4	Fixed format ASCII	0.2	6 months following deployment end	FTP to NSIDC

3.2.1.2 Narrow Swath Airborne Topographic Mapper

The NASA IceBridge Narrow Swath ATM Level-1B Qfit Elevation and Return Strength (ILNSA1B) data set contains spot elevation measurements of Greenland, Arctic, and Antarctic sea ice acquired using the NASA ATM 4CT3 narrow scan instrumentation.

Table 3.6. Narrow Swath ATM Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILNSA1B	IceBridge Narrow Swath ATM L1B Qfit Elevation and Return Strength	1B	HDF5	30	6 months following deployment end	FTP to NSIDC
ILNSA2	IceBridge Narrow Swath ATM L2 Ice Surface Elevation	2	Fixed format ASCII	2	6 months following deployment end	FTP to NSIDC

3.2.1.3 Continuous Airborne Mapping By Optical Translator (CAMBOT)

The NASA IceBridge CAMBOT L1B Geolocated Images data set contains images taken over Antarctica and Greenland. The data set contains original CAMBOT files and full size Joint Pictures Expert Group (JPEG) images, with associated Keyhole Markup Language (KML) files, rotated and reduced-resolution Portable Network Graphics (PNG) image files, and position, altitude and trajectory files.

Table 3.7. CAMBOT Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IOCAM1B	IceBridge CAMBOT L1B Geolocated Images	1B	jpeg	500	6 months following deployment end	Hard drive

3.2.1.4 KT19 Infrared Radiation Pyrometer

The NASA IceBridge KT19 IR Surface Temperature data set contains surface temperature measurements of Arctic sea ice and land ice acquired using the Heitronics KT19.85 Series II Infrared Radiation Pyrometer alongside the NASA ATM instrument.

Table 3.8. KT19 Infrared Radiation Pyrometer Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAKST1B	IceBridge KT19 IR Surface Temperature	1B	Fixed format ASCII	0.5	6 months following deployment end	FTP to NSIDC

3.3 NASA Goddard Space Flight Center

NASA's Land, Vegetationand Ice Sensor (LVIS), which also includes data from an integrated inertial navigation system (INS) and GPS, is designed, developed and operated by the Laser Remote Sensing Laboratory, at NASA’s Goddard Space Flight Center.

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3.3.1 Instruments and Science Data Products

3.3.1.1 Land, Vegetationand Ice Sensor

LVIS is a scanning laser altimeter instrument that is flown, by aircraft, over target areas to collect data on surface topography, surface roughness, and vegetation coverage. LVIS has a scan angle of 12 degrees, which produces a 2 km wide swath from a 10-kilometer flight altitude. LVIS is a full-waveform laser altimeter, and, as such, the transmit and return waveforms are collected for each laser shot and released as the LVIS L1B product.

Table 3.9. LVIS Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILVIS0	IceBridge LVIS L0 Raw Ranges	0		500	1 month following deployment end	Hard drive
ILVIS1B	IceBridge LVIS L1B Geolocated Return Energy Waveforms	1B	HDF5	300	6 months following deployment end	FTP
ILVIS2	IceBridge LVIS L2 Geolocated Surface Elevation Product	2	Fixed format ASCII	30	6 months following deployment end	FTP
IPPLV1B	IceBridge LVIS POS/AV L1B Corrected Position and Attitude Data	1B	sbet	20	6 months following deployment end	FTP

3.4 National Suborbital Education and Research Center (NSERC)

The NSERC is the product of a cooperative agreement between NASA and the University of North Dakota.

NSERC supports science mission operations and aircraft deployments for Earth science research campaigns conducted by the NASA Airborne Science Program. NSERC provides payload integration engineering, data display and networking, and facility instrumentation for NASA's fleet of research aircraft, including the DC-8 and P-3B airborne laboratories, the WB-57 high altitude platform, and the Global Hawk Uninhabited Aerial Vehicle, among others.

NSERC is also responsible for education and outreach activities for the Airborne Science Program, including organization and operation of the Student Airborne Research Program (SARP), a college-level summer internship that provides hands-on research experience in airborne science using NASA's flying laboratories.

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3.4.1 Instruments and Science Data Products

3.4.1.1 On-board Meteorology Suite

This is a collection of airborne in-flight meteorological and in-cabin measurements, and thermal emission measurements of near-nadir surface skin temperature. Instruments flown over Antarctica include cabin pressure transducer, 3-stage hygrometer, 2-stage hygrometer, total air temperature sensor, and infrared surface temperature pyrometer. The data files contain measurements for 36 meteorological, surface characteristic, and positional variables.

Table 3.10. On-board Meteorology Suite Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAMET1B	IceBridge NSERC L1B Geolocated Meteorologic and Surface Temperature Data	1B	ICARTT	<1	1 month after deployment	FTP

3.5 Cirrus Digital Systems

Cirrus Digital Systems is a California based company that processes Digital Mapping System (DMS) stereographic imagery and ATM Lidar into a Level 3 Hybrid Surface Model (HSM). The HSM possesses the elevation accuracy of ATM and visual realism and surface resolution of DMS imagery.

Provider POCs	Email Address
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3.5.1 Instruments and Science Data Products

3.5.1.1 Cirrus HSM

Table 3.11. Cirrus HSM

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IODMS3	IceBridge DMS + ATM Hybrid Surface Model	3	geotiff	~2000	6 months (requires L1B ATM data)	Hard Drive or BD-ROM

3.6 University Affiliated Research Center (UARC)

The University of California Santa Cruz has established and is leading a University Affiliated Research Center (UARC) at NASA Ames. In September 2003, the University of California (UC) was awarded a ten-year research contract by NASA Ames. Research under this contract focuses on information technology, biotechnology, nanotechnology, computer science, aerospace operations, astrobiology and fundamental biology. The UARC conducts long-term focused research tasks in NASA's growing multidisciplinary research mission needs.

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3.6.1 Instruments and Science Data Products

3.6.1.1 Digital Mapping System Camera

The DMS is an airborne digital camera that acquires high resolution natural color and panchromatic imagery from low and medium altitude research aircraft. Data acquired by DMS are used by a variety of scientific programs to monitor variation in environmental conditions, assess global change, and respond to natural disasters.

The DMS instrument is maintained and operated by the Airborne Sensor Facility (ASF) located at the NASA Ames Research Center in Mountain View, California, under the oversight of the Earth Observing System (EOS) Project Science Office at NASA Goddard.

Table 3.12. Digital Mapping System Camera

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IODMS0	IceBridge DMS L0 Raw Imagery	0	jpg	5120	90 days	Hard drive
IODMS1B	IceBridge DMS L1B Geolocated and Orthorectified Images	1B	geotiff	9216	90 days	Hard drive
IPAPP1B	IceBridge POS/AV L1B Corrected Position and Attitude Data	1B	sbet	35	90 days	FTP

3.7 Lamont-Doherty Earth Observatory

Lamont-Doherty Earth Observatory seeks fundamental knowledge about the origin, evolution and future of the natural world. Its scientists study the planet from its deepest interior to the outer reaches of its atmosphere, on every continent and in every ocean, providing a rational basis for the difficult choices facing humanity.

Lamont-Doherty is a core component of the Earth Institute, Columbia University, which brings together people and tools to address some of the world's most challenging problems from climate change and environmental degradation, to poverty, disease and the sustainable use of resources. Lamont-Doherty also operates a federally funded research ship, the Marcus G. Langseth, which uses seismic data to map the sub-seafloor, highlighting hidden faults and other earthquake hazards

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3.7.1 Instruments and Science Data Products

3.7.1.1 Magnetometer

The NASA IceBridge Scintrex CS-3 Cesium Magnetometer records magnetic field readings and fluxgate values.

Table 3.13. Magnetometer

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IMCS30	IceBridge Scintrex CS-3 Cesium Magnetometer L0 Raw Magnetic Field	0	ASCII	20 (unzipped)		FTP
IMCS31B	IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies	2	ICARTT	2 –4	4-5 Months after campaign	FTP

3.7.1.2 Gravimeter

This gravimeter is a Sander Geophysics AIRGrav airborne gravity system. The AIRGrav data consist of measurements of aircraft attitude and acceleration. Aircraft attitude is provided as one file per flight. Gravity data include latitude and Eötvös corrected values, and the free air correction at various along-flight-line spatial filtering scales. Gravity data are organized temporally.

Table 3.14. Gravimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IGGRV1B	IceBridge Sander AIRGrav L1B Geolocated Free Air Gravity Anomalies	2	ICARTT	2 – 4	4-5 Months after campaign	FTP
IGBTH3	IceBridge Sander AIRGrav L3 Bathymetry	4	ASCII	Varies – but less than 1	1 year	FTP

3.8 University of Texas

The University of Texas Institute for Geophysics (UTIG) is an academic research center best known for projects with an international scope. Prominent research areas include marine geology and geophysics, tectonics, terrestrial and lunar seismology, quantitative and exploration geophysics, and geophysical studies of ice sheets and of climate.

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3.8.1 Instruments and Science Data Products

3.8.1.1 GPS / Inertial Measurements

Two GPS-aided Inertial Measurement Units (IMU) are included in this suite. One is standalone and one is integrated with the Scanning Lidar.

Table 3.15. GPS / IMU

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IPUTG0	IceBridge GPS L0 Raw Satellite Navigation Data	0	ELSA/ NMEA	1	2 months post field; non critical	FTP
IPUTI0	IceBridge IMU L0 Raw Inertial Measurement Unit Data	0	ELSA/ MMQ-50/Novatel	1	2 months post field; non critical	FTP
IPUTG1B	IceBridge GPS/IMU L1B Primary Position and Attitude Solution	1B	ASCII	<1	4 months post field	FTP
IPUTN1B	IceBridge GPS L1B Time-Tagged Real-Time Position and Attitude Solution	1B	ASCII	<1	2 months post field	FTP
ITKTC0	IceBridge L0 Raw Kinematics GPS Time Codes	0	ELSA/ ASCII time stamps	<1	2 months post field; non critical	FTP

3.8.1.2 Gravimeter

Three gravimeters have been used by Texas for Ice Bridge: a Bell Aerospace BGM-3 (#203); a ZLS Corporation ZLS (#S-83); and a Canadian Microgravity GT-1A (#3).

Table 3.16. Gravimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IGBGM0	IceBridge BGM-3 Gravimeter L0 Raw Accelerations	0	ELSA/ Counts per second	<1	2 months post field; non critical *(retired after AN11)*	FTP
IGBGM1B	IceBridge BGM-3 Gravimeter L1B Time-Tagged Accelerations	1B	ASCII	<1	2 months post field; *(retired after AN11)*	FTP
IGBGM2	IceBridge BGM-3 Gravimeter L2 Geolocated Free Air Anomalies	2	ASCII	<1	4 months post field; *(retired after AN11)*	FTP
IGZLS0	IceBridge ZLSGravimeter L0 Raw Accelerations	0	Fixed width ASCII/ ZLS	<1	2 months post field; non critical *(only used for AN11)*	FTP
IGZLS1B	IceBridge ZLS Gravimeter L1B Time-Tagged Accelerations	1B	ASCII	<1	2 months post field; *(only used for AN11)*	FTP
IGCMG1B	IceBridge GT1A Gravimeter L1B Time-Tagged Accelerations	1B	ASCII	<1	2 months post field; *(only used for AN12)*	FTP
IGCMG2	IceBridge GT1A Gravimeter L2 Geolocated Free Air Anomalies	2	ASCII	<1	4 months post field; *(only used for AN12)*	FTP

3.8.1.3 High Capability Radar Sounder (HiCARS)

This is a Very High Frequency (VHF) ice-penetrating radar which operates in frequency-chirped mode from 52.5 to 67.5 MHz. HiCARS allows for phase coherent recording of radar returns for advanced processing. For antennas the system uses twin flat dipoles, one mounted under each aircraft wing providing approximately 18 dB of two-way antenna gain. The peak instantaneous output power is 8kW.

Table 3.17. HiCARS

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IR1HI0	IceBridge HiCARS 1 L0 Raw Return Energy Amplitudes	0	16-bit offset video Binary	1500	2 months post field; non critical *(retired after AN10)*	HardDrive
IR1HIB	IceBridge HiCARS 1 L1B Geolocated Radar Records	1B	NetCDF	120	2 months post field; *(retired after AN10; format pending NSIDC approval)*	HardDrive
IR1HI2	IceBridge HiCARS 1 L2 Geolocated Ice Thickness	2	ASCII	<1G	4 months post field; *(retired after AN10)*	FTP
IR2HI0	IceBridge HiCARS 2 L0 Raw Return Energy Amplitudes	0	16-bit offset video Binary	1500	2 months post field; non critical (*used after AN10)*	HardDrive
IR2HI1B	IceBridge HiCARS 2 L1B Geolocated Radar Records	1B	NetCDF	120	2 months post field; *(used after AN10 format pending NSIDC approval)*	HardDrive
IR2HI2	IceBridge HiCARS 2 L2 Geolocated Ice Thickness	2	ASCII	<1	4 months post field; *(retired after AN10)*	FTP

3.8.1.4 Laser Altimeter

This is a fixed, nadir pointing Riegl laser altimeter, which is the predecessor to the scanning, Sigma Space lidar.

Table 3.18. Laser Altimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILUTP0	IceBridge Riegl Laser Altimeter L0 Raw Ranges	0	ELSA/ Riegl	<1	2 months post field; non critical	FTP
ILUTP1B	IceBridge Riegl Laser Altimeter L1B Time-Tagged Laser Ranges	1B	ASCII	<1	2 months post field	FTP
ILUTP2	IceBridge Riegl Laser Altimeter L2 Geolocated Surface Elevation Triplets	2	ASCII	<1	4 months post field	FTP

3.8.1.5 Scanning Lidar

This is a multibeam, scanning photon-counting lidar built by Sigma Space. It images the surface below the aircraft with one hundred laser beamlets. This system is mechanically scanned in a swath either side of the flight path. A one hundred channel photon counting receiver captures return photons and records time of flight and time tag data allowing a three dimensional reconstruction of the surface. At a survey elevation of 800 meters, swath width is around 400 meters.

Table 3.19. Scanning Lidar

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILSSP0	IceBridge Sigma Space Prototype L0 Raw Time-of-Flight Data	0	Sigma Space binary	~1000 to 3000	2 months post field; non critical *(Retired after AN09)*	HardDrive
ILSIG0	IceBridge Sigma Space Lidar L0 Raw Time-of-Flight Data	0	Sigma Space binary	~1000 to 3000	2 months post field; non critical	HardDrive
ILSNP1B	IceBridge Sigma Space Photon Counting Lidar L1B Time-Tagged Nadir Photon Ranges	1B	HDF5 (details TBD)	~1000	4 months post field	HardDrive
ILSNP2	IceBridge Sigma Space Photon Counting Lidar L2 Geolocated Nadir Photon Elevations	2	ASCII	<1	4 months post field	FTP

3.8.1.6 Magnetometer

There are two magnetometer used for these products. One is a cesium vapor magnetometer used for scalar geomagnetic field strength measurements. The other is a three-axis fluxgate magnetometer used to provide vector magnetic field data for use by the cesium magnetometer.

Table 3.20. Magnetometer

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IMFGM0	IceBridge Flux Gate Magnetometer L0 Raw Magnetic Field	0	ELSA/3 channel voltages (HEX)	<1	2 months post field; non critical	FTP
IMGEO0	IceBridge Geometrics 823A Cesium Magnetometer L0 Raw Magnetic Field	0	ELSA/ Geometrics	<1	2 months post field; non critical	FTP
IMGEO1B	IceBridge Geometrics 823A Cesium Magnetometer L1B Time-Tagged Magnetic Field	1B	ASCII	<1	2 months post field	FTP
IMGEO2	IceBridge Geometrics 823A Cesium Magnetometer L2 Geolocated Magnetic Anomalies	2	ASCII	<1	2 months post field	FTP

3.8.1.7 Pressure Altimeter

This instrument measures air pressure via a Paroscientific S-1000 Digiquartz Transmitter.

Table 3.21. Pressure Altimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAPRS0	IceBridge Paroscientific S-1000 L0 Pressure Altimeter Raw Air Pressure	0	ELSA	<1	2 months post field; non critical	FTP
IAPRS1B	IceBridge Paroscientific S-1000 L1B Pressure Altimeter Time-Tagged Air Pressure	1B	ASCII	<1	2 months post field	FTP

3.9 University of Alaska Fairbanks

The University of Alaska Fairbanks (UAF) is a public research university home to seven major research areas. The Geophysical Institute is one of the seven that conducts research into space physics, atmospheric science, seismology, tectonics, and sedimentation.

Provider POCs	Email Address
Chris Larsen	chrislarsen.ak@gmail.com

3.9.1 Instruments and Science Data Products

3.9.1.1 Glacier Lidar

This Glacier Lidar system is capable of generating both surface profiles and scanned altimetry data.

Table 3.22. Glacier Lidar

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILAKS1B	IceBridge UAF Lidar Scanner L1B Geolocated Surface Elevation Triplets	1B	LAS	135 (two campaigns per year, this is the total for one year)	3 months after campaign	FTP
IPUAF1B	IceBridge UAF GPS/IMU L1B Corrected Position and Attitude Data	1B	ASCII	1	3 months after campaign	FTP

3.10 University of California Irvine

The University of California Irvine's (UCI) department of Earth System Science supports the Rignot Research Group. Relative to IceBridge, the group measures ice thickness with an airborne ground penetrating radar called the Warm Ice Sounding Explorer (WISE) which operates at a center frequency of 2.5 MHz and is optimized to probe temperate ice.

Provider POCs	Email Address
Eric Rignot	eric.j.rignot@jpl.nasa.gov
Jeremie Mouginot	jmougino@uci.edu
Bernd Scheuchl	bscheuch@uci.edu

3.10.1 Instruments and Science Data Products

3.10.1.1 WISE

This sounder uses 120-meter long wavelengths to penetrate past rough ice surfaces, voids, water pockets, water-filled cracks, and temperate ice (ice at the in-situ-pressure melting point) before they are reflected by the interface between ice and the glacier bed. This makes the system well suited for the study of outlet glaciers with challenging internal structure, i.e. highly absorptive or scattering heterogeneities associated with the presence of liquid water pockets within the ice.

Table 3.23. WISE

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
WISE1B	IceBridge WISE L2 Geolocated Ice Thickness	2	ASCII	<1	6 months	FTP

3.11 University of Colorado/CULPIS-X

The research group developing CULPIS-X is part of the Colorado Center for Astrodynamics Research (CCAR) in the Department of Aerospace Engineering at the University of Colorado, Boulder. This group has previously deployed instruments aboard unmanned aircraft in both Arctic and Antarctic locations.

Provider POCs	Email Address
James Maslanik	James.Maslanik@colorado.edu
Mark Tschudi	mark.tschudi@colorado.edu

3.11.1 Instruments and Science Data Products

The following instruments are planned for deployment within the CU Lidar Profilometer and Imaging System – extended (CULPIS-X) instrument package: a laser rangefinder (CULPIS), a still camera (Canon G10), an Everest Pyrometer (ice surface temperature), and an Ocean Optics profiling spectrometer (surface reflectance). The CULPIS-X would deploy once per month aboard a Coast Guard C-130 from Kodiak, AK, flying over the Bering, Chukchi, and Beaufort Seas. The initial deployment date is to be determined (TBD), as the Coast Guard is currently evaluating the package for airworthiness.

Table 3.24. CULPIS-X

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
CUULSL0	CULPIS-X L0 ULS lidar raw data	0	ASCII	18 GB for full year (9 campaigns per year)	3 mos after final flight	ftp
CUULRL1	CULPIS-X L1 range data	1	ASCII	18 GB for full year	6 mos after final flight	ftp
CUGPSL0	CULPIS-X L0 GPS data	0	ASCII	12 GB for full year	3 mos after final flight	ftp
CUGPCL0	CULPIS-X L0 Carrier-phase	0	Binary	12 GB for full year	3 mos after final flight	ftp
CUIMSL0	CULPIS-X L0 IMS data	0	ASCII	12 GB for full year	3 mos after final flight	ftp
CUPRSL0	CULPIS-X L0 Barometric Pressure	0	ASCII	12 GB for full year	3 mos after final flight	ftp
CUTMPL0	CULPIS-X L0 Internal Temperature	0	ASCII	12 GB for full year	3 mos after final flight	ftp
CUISTL0	CULPIS-X raw IST data	0	ASCII	4 GB for full year	3 mos after final flight	ftp
CAIST1B	CULPIS-X L1B IST	1B	ASCII	4 GB for full year	4 mos after final flight	ftp
CUSRF1B	CULPIS-X L1B Surface Reflectance	1B	NetCDF	50 GB for full year	4 mos after final flight	ftp
CUCAM1B	CULPIS-X L1B Camera Imagery	1B	JPEG	324 GB for full year	4 mos after final flight	ftp

3.12 Miscellaneous

3.12.1 Data Products

3.12.1.1 Flight Reports

Table 3.25. Flight Reports

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IFLTRPT	IceBridge Mission Flight Reports	n/a	PDF			

3.12.1.2 Derived Products

The NASA IceBridge Sea Ice Freeboard, Snow Depth, and Thickness (IDCSI2) data set contains derived geophysical data products including sea ice freeboard, snow depth, and sea ice thickness measurements in Greenland and Antarctica retrieved from IceBridge Snow Radar, DMS, CAMBOT, and ATM data sets. The data were collected as part of Operation IceBridge funded campaigns, are stored in American Standard Code for Information Interchange (ASCII) text files, and are available via File Transfer Protocol (FTP) for periodic, ongoing campaigns from 31 March 2009 to the present.

Provider POCs	Email Address
Michael Studinger	michael.studinger@nasa.gov
Nathan Kurtz	nathan.t.kurtz@nasa.gov
Christy Hansen	christy.hansen-1@nasa.gov

Table 3.26. Sea Ice Science Data Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IDCSI2	IceBridge Sea Ice Freeboard, Snow Depth, and Thickness	2	ASCII	< 1	12 month following deployment end	FTP

The following Tomographic derived products were developed by NASA Jet Propulsion Laboratory (JPL) for swath ice sounding. Data was collected by the MCoRDs instrument and processed into bedmap products: ice thickness maps, ice thickness error maps, basal elevation maps, and basal reflectivity maps.

Provider POCs	Email Address
Xiaoqing Wu	Xiaoqing.Wu@jpl.nasa.gov

Table 3.27. Tomographic Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
	Tomographic Ice Thickness Map					
	Tomographic Ice Thickness Error Map					
	Tomographic Base Elevation Map					
	Tomographic Base Reflectivity Map					

4 Data Stewardship

The NSIDC DAAC, with support from the ESDIS Project, is responsible for ingest, archive, and distribution of all IceBridge data products. This includes Level 0 data (where specified), higher level products, ancillary data, metadata, algorithm source code, documentation, and other information in accordance with EOS Data and Information System (EOSDIS) archive policies. Responsibilities also include the distribution of the above-mentioned products to users in accordance with the IceBridge mission and EOSDIS data distribution policies. Public release of these data shall conform to the NASA Earth Science Data and Information Policy, which can be found at: http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/.

Previously, NSIDC used an abbreviated ingest process ("fasttrack") which circumvented the approved NASA processes and standards in order to make data available as quickly as possible, and enabled data providers to deliver data with minimal metadata and documentation. That process will no longer be available. All data will be delivered to NSIDC using the steps described below unless ESDIS and the IceBridge Project Science Office grant specific exceptions.

In order to ensure that NASA's expectations for data preservation and usability are met, NSIDC may delay publication of any data set that is not delivered with full documentation (as specified in the NASA documentation content specifications) or that does not meet delivery requirements.

4.1 Acceptance of New Data Sets

Before a new IceBridge data product is sent to the NSIDC DAAC, the following steps must first be implemented:

4.1.1 A description of the data product in question will be documented by the provider and sent to the Operation IceBridge Project Science Office, the ESDIS Project, and the NSIDC DAAC. This description will include:

a. A description of the science content of the data product and its relevance to Operation IceBridge science requirements.

b. Level of product (0-4)

c. Expected data volume (per life of mission)

d. Current archive location

4.1.2 Review by ESDIS and the Project Science Office. Any new product that is proposed will be reviewed by ESDIS and the Operation IceBridge Project Science Office to make sure that the product is scientifically relevant, within the scope of the Operation IceBridge mission objectives, and that sufficient resources are available to support it. An evaluation of its current archive status will be made to determine if the product can be "brokered", or linked, from its existing location rather than ingested into NSIDC's data archive. Only when data is judged to be safely archived and sufficiently documented will a brokering arrangement be considered. In the case of brokering, NSIDC enables discovery of the data through appropriate links, but bears no further responsibility to the data.

4.1.3 Create appropriate short names and long names for each data product. NSIDC will do this in conjunction with the provider.

4.1.4 ESDIS will update this Data Management Plan.

4.2 Data Submission Process

This process applies to all IceBridge data sets that are not currently archived in NSIDC's Earth Core System (ECS) system (unless ESDIS and the IceBridge Project Science Office grant an exception). As of March 2013, only UARC has been granted said exception for the DMS data sets.

Before the first submission, each provider must, in coordination with ESDIS' EOSDIS Evolution and Development (EED) Contractor and NSIDC, create and validate an Earth Science Data Type (ESDT) that defines the structure of the data set. Once created, the ESDT is maintained as long as the data set structure does not change.

The provider is responsible for initiating updates to the ESDT and notifying NSIDC if changes are planned to the content or structure of the data set. The ESDT must be consistent with the content of expected data delivery.

In order to efficiently ingest data into NSIDC's ECS system, ESDIS has created (through its ECS contractor) a generic tool for creation of necessary metadata and associated files. This tool, called "MetGen", is given to each provider along with associated configuration files for its correct operation.

Details of how to run the MetGen tool will be included with the tool package. Details of how data ingestion to NSIDC will now work using MetGen can be found in the IceBridge Science Investigator-led Processing System (SIPS) Operational Concept Document located at: http://nsidc.org/data/icebridge/IceBridgeSIPSOpsConv1_5.docx.

The providers retain full responsibility for data and control over metadata quality. This process is simply a mechanism for automated ingest to NSIDC.

4.2.1 Before the first submission, the provider is responsible for performing integration testing with NSIDC to ensure that data will routinely be ingested successfully without excessive manual intervention by NSIDC's Operations staff.

4.2.2 The provider is responsible for running the MetGen tool and creating the necessary metadata and Product Delivery Record (PDR) files before each data submission. After receipt of ingest status notices from ECS, the provider (with support from NSIDC and the ECS contractor) is responsible for all error correction and re-delivery.

4.3 Naming Conventions

Science data files and their associated supporting files (such as browse, quality assurance, preliminary metadata ("premet"), and spatial files) must use a standard naming convention. A file and its associated files should use the same name; the file extension distinguishes the data file from the associated files. File names should include the ESDT shortname, date and time of data collection, version identification, and any additional information that might be needed to uniquely identify the data file.

Example, for ATM L1B data:

Data file: ILATM1B_V01_04212010_04452366_A.h5

Premet file: ILATM1B_V01_04212010_04452366_A.premet

Spatial file: ILATM1B_V01_04212010_04452366_A.spatial

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Abbreviations and Acronyms

AK	Alaska
ASCII	American Standard Code for Information Interchange
ASF	Airborne Sensor Facility
ATM	Airborne Topographic Mapper
CAMBOT	Continuous Airborne Mapping by Optical Translator
CCAR	Colorado Center for Astrodynamics Research
CReSIS	Center for Remote Sensing of Ice Sheets
CSV	Comma Separated Value
CULPIS-X	CU Lidar Profilometer and Imaging System – extended
DAAC	Distributed Active Archive Center
dB	Decibel
DCN	Document Change Notice
DMS	Digital Mapping System
ECS	EOSDIS Core System
EED	EOSDIS Evolution and Development
ELSA	Environment for Linked Stream Acquisition
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESD	Earth Science Division
ESDIS	Earth Science Data and Information System
ESDT	Earth Science Data Type
FTP	File Transfer Protocol
GB	Giga Byte 10^9 bytes
GHZ	Giga Hertz
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HEX	Hexadecimal

HiCARS	High Capability Radar Sounder
HSM	Hybrid Surface Model
ICARTT	International Consortium for Atmospheric Research on Transport and Transformation
ICESat	Ice, Cloud and Land Elevation Satellite
IMU	Inertial Measurement Units
INS	Inertial Navigation System
JPEG	Joint Pictures Expert Group
JPL	Jet Propulsion Laboratory
Km	Kilometers
KML	Keyhole Markup Language
L0 – L4	Level 0 through Level 4
LAS	Live Access Server
LIDAR	Laser Imaging Detection and Ranging
LVIS	Land, Vegetation, and Ice Sensor
MB	Mega Byte 10^6 bytes
Mbps	Mega bits per second
MCoRDS	Multichannel Coherent Radar Depth Sounder
MHz	Mega Hertz
NASA	National Aeronautics and Space Administration
NMEA	National Marine Electronics Association
NetCDF	Network Common Data Form
NSERC	National Suborbital Education and Research Center
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
PDR	Product Delivery Record
PNG	Portable Network Graphics
POC	Point of Contact
POS	Product Order Status
SAR	Synthetic Aperture Radar
SARP	Student Airborne Research Program
SIPS	Science Investigator-led Processing System

STC	Science and Technology Center
TBD	To Be Determined
UAF	University of Alaska Fairbanks
UARC	University Affiliated Research Center
UC	University of California
UCI	University of California Irvine
UTIG	University of Texas Institute for Geophysics
VHF	Very High Frequency
WISE	Warm Ice Sounding Explorer
ZLS	Zero-Length Spring Corporation